

Computer Science

A TOOLKIT FOR DEVELOPING VISUALIZATIONS OF TREE BASED DATA STRUCTURES AND ALGORITHMS

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This paper describes the development of a toolkit for the easy creation of visualizations involving tree data structures and algorithms. This work is part of a broader effort in algorithm visualization¹ that utilizes the JHAVE system developed by Thomas Naps². JHAVE provides interactive and animated visualizations of common data structures, engages students through intermittent questioning to test their understanding of course material, and allows teachers to create their own examples of data structures. JHAVE works by incorporating various visualization systems. Our work focused on the Animal visualization system developed by Guido Roessling³.

Animal is a script-based language that allows the user to create smooth running animations of moving shapes, lines, and arcs. Our research focus was to allow users to generate and manipulate higher order tree-based visual elements such as labeled tree nodes and edges. We created a toolkit that anyone with a minimal understanding of Java could use to create accurate and aesthetically pleasing examples of data trees. Guidelines for these “tidy trees” were researched in Sven Moen’s “Drawing Dynamic Trees⁴,” and include rules for node placement, vertical and horizontal spacing between nodes, and symmetry among branches. The resulting animations would then be inserted into the JHAVE environment for use by end-users. Care was given to creating an underlying tree structure that supports both binary and general trees, and to animating those trees while taking up minimum space. Methods, or the basic building tools, had to be convenient and helpful without taking too much power away from the user. Finally, care had to be taken that the work could be easily assimilated into JHAVE and that there was continuity with the work of other researchers who were creating classes to support graphs and arrays.

The end product is an easily extendable toolbox for building Animal animations of tree data structures. The program works by taking simple method calls in Java and generating actual Animal script that can then be loaded and displayed by the Animal program. The toolkit user can change everything about the tree from the size of the nodes to the distance of separation between branches. Users can also develop customized methods for node insertion, node deletion, and other tree-based operations. We have developed example animations using this system and have created an extensive reference manual for users.

¹ Grissom, S., McNally, M., and Naps, T. *Integrating Algorithm Visualizations into Computer Science Education*, NSF-CCLI (DUE-0126494)

² Eagon, J., Naps, T. and Norton, L. “JHAVE - An Environment to Actively Engage Students in Web-based Algorithm Visualizations,” *Proceedings of the SIGCSE Technical Symposium*, Austin, TX, March, 2000.

³ Freisleben, B., and Roessling, G. “ANIMALSCRIPT: An Extensible Scripting Language for Algorithm Animation,” *Proceedings of the SIGCSE Technical Symposium*, Charlotte, NC, February, 2001.

⁴ Moen, S. “Drawing Dynamic Trees,” *IEEE Software* 7(4): 21-28 (1990)